Calculating Riser Dynamic Effects on Spar Motions in Waves

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ABSTRACT

Riser and mooring that are hanging off from offshore platforms move with and constrain the platform motions in waves. In some industrial practice, effects of mooring line dynamics and riser dynamics may be neglected, i.e., with an uncoupled analysis model, resulting in conservative predictions of the platform motion responses. Riser and mooring dynamic effects are actually important factors for accurately calculating the platform motions in waves. As for a case study, associated with a sample spar platform, risers are modeled as Bernoulli-Euler beams and the dynamic effects are thus accounted for. The spar motions are simulated using this so-called “coupled” analysis, comparing to the “uncoupled” quasi-static analysis. Observations were made that riser’s dynamics shows different magnitudes in various wave conditions. The uncoupled analysis typically results in very conservative motion responses in medium and low seastates, potentially leading to difficult challenges and high costs for riser fatigue design, in particular, near riser hang-off and seafloor touch-down regions. The coupled analysis thus becomes necessary for a feasible and cost effective solution for the riser.

KEY WORDS:
Spar, Motions, Coupled Analysis, Fatigue Seastates

INTRODUCTION

The discussion on the global coupled analysis of floating production platform integrating the vessel, riser and mooring systems, has been recognized over two decades and reported in the many literatures (Pauling and Webster, 1986; Kim et al., 1994; Kim et al., 2001; Gupta et al., 2000; Senra et al., 2002; Tahar and Kim, 2003; Garrett, 2005; Low and Grime, 2010). Pauling and Webster (1986) and Kim et al. (1994) showed coupled analysis application in TLP response. Kim et al. (2001) and Gupta et al. (2000) applied coupled analysis in Spar analysis. Tahar and Kim (2003), Low and Grime (2010) displayed coupled analysis in FPSO design. Senra et al. (2002) and Garrett (2005) summarized the coupled analysis in semisubmersible application. Although coupled analysis has been proposed by many people and studied for different floaters and offshore fields, it has not been fully considered in the past engineering practice. Computational efficiency is a significant issue since typical programs to compute platform motions and typical programs to compute rod dynamics are both computationally intensive. Coupling of these two programs can easily lead to simulation times that greatly exceed real time and this limits the utilization of these programs in the design of sophisticated new platforms. Also, the uncoupled analysis excluding damping and inertia contributions from moorings and risers, is thought to be conservative and provide the necessary design redundancy.

As the offshore exploration and production go to deeper water, the effects of elongated mooring and riser systems become increasingly significant when designing the floater system and predicting its behaviors. The viscous damping and inertia mass from moorings and risers become indispensable in order to properly understand and accurately predict the floater responses. The exclusion of coupling effects may result in costly engineering over-design. Recently, Technip developed the asynchronous coupling scheme joined with MLTSIM and RodDyn programs (Jing et al. 2011) for reducing the computation time required for consistent coupled platform/rod dynamics simulations by exploiting the time scale differences between the wave and platform time scales and typical rod dynamics time scales. Thus, the effective and efficient simulation tools provide a viable solution to batch run global performance analysis in various environments, especially for fatigue sea states.

For Spar platforms, the large draft of the Spar platform adequately constrains the heave response due to first order wave excitation, but the low frequency floater motions need to be considered and taken into account. The coupling effects from mooring and riser systems generally contribute to suppress the low-frequency response of the Spar. The floating platform tends to interact more pronouncedly with mooring and riser systems, especially in low and median fatigue sea states.

The paper describes the MLTSIM-RodDyn model used for the coupled analysis, combining the rod model based on Euler-Bernoulli beam theory (simple beam theory) with large deflections, and coupling of platform dynamics and rod dynamics.